ICSE
Living Science
Physics

Class 9

Chapter 10 Spherical Mirrors

As per the guidelines of NEP 2020

On Board! BOOKS

Revised and Updated

Living Science Physics

Based on the latest ICSE syllabus

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LEARNING OBJECTIVES

Reflection of Light from Curved Surfaces

- **Spherical mirrors**
- **Terms related to spherical mirrors**
- **Relationship between the focal length and radius of curvature**
- **Rules for the formation of images by a spherical mirror**
- **Formation of images by a concave mirror**
- **Formation of images by a convex mirror**
- **Uses of spherical mirrors**

New Cartesian Sign Convention

Mirror Formula

What is a spherical mirror?

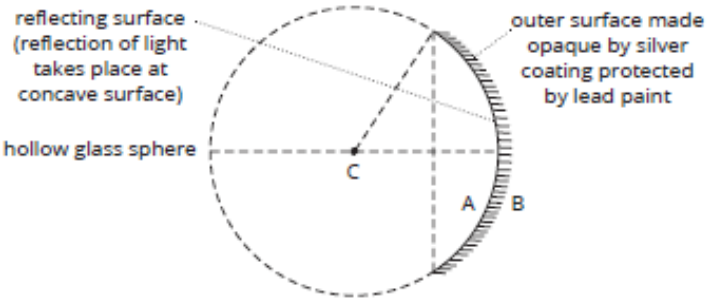
A spherical mirror is that mirror whose polished, reflecting surface is the part of a hollow sphere of glass.

In a spherical mirror, one of the two curved surfaces is coated with a thin layer of silver metal followed by a coating of red lead oxide paint. Thus, one side of the spherical mirror is made opaque and the other side acts as a reflecting surface. The opaque side of a mirror is shown shaded.

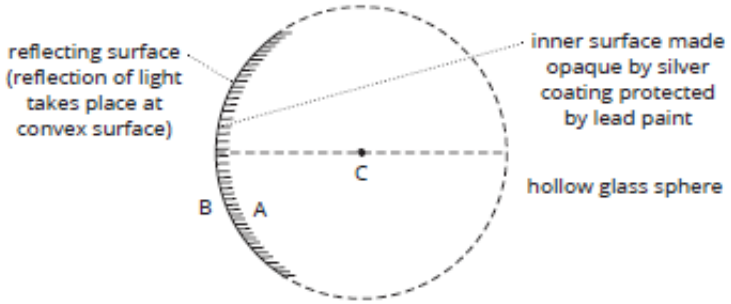
Types of Spherical Mirrors

Concave mirror: A spherical mirror whose inner hollow surface is the reflecting surface is called a **concave mirror**. The reflection of light takes place at the concave surface (or bent-in surface) marked A.

Convex mirror: A spherical mirror whose outer surface is the reflecting surface is called a **convex mirror**. The reflection takes place at the convex surface (or bulging out surface) marked B .



a. Concave mirror



b. Convex mirror

Terms related to spherical mirrors

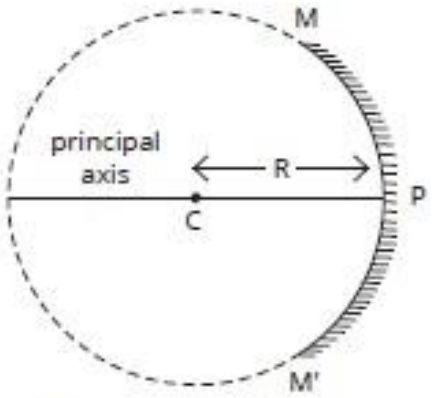
1. Aperture: The effective width (distance) of the spherical mirror from which reflection of light can take place is called its aperture.

2. Pole: The centre of a spherical mirror is called its pole. It is denoted by P. It is the middle point of a spherical mirror.

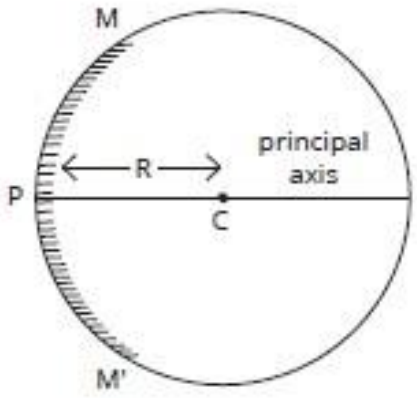
3. Centre of curvature: The geometric centre of the hollow sphere which the spherical mirror is a part is called the centre of curvature the spherical mirror. It is denoted by C. The centre of curvature of a concave mirror is in front of it but the centre of curvature of a convex mirror is located behind it.

4. Radius of curvature: The radius of the hollow sphere of which the spherical mirror is a part is called the radius of curvature of the spherical mirror. In other words, the distance between the pole and the centre of curvature of the spherical mirror (PC) is called its radius of curvature. It is denoted by *R*.

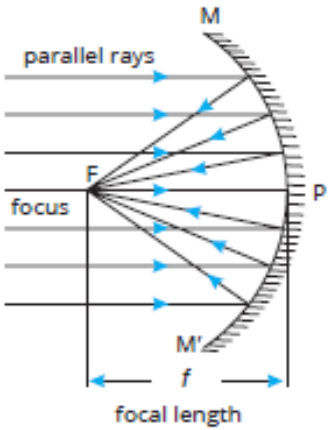
5. Principal axis: The straight line passing through the centre of curvature and the pole of a spherical mirror is called its principal axis.



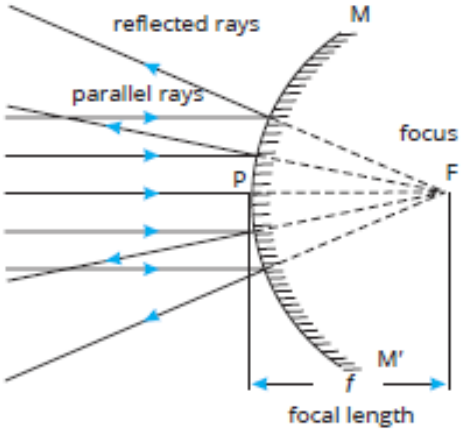
a. Concave mirror



b. Convex mirror



a. Concave mirror



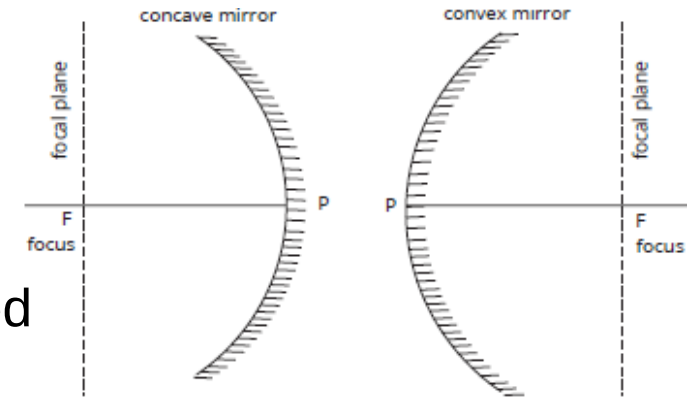
b. Convex mirror

6. Focus: If a beam of light parallel to the principal axis falls on a concave mirror, all the rays after reflection meet at a point. This point is called the focus (F) or **focal point of the concave mirror**. This is why a concave mirror is called a **converging mirror.** The focus of a concave mirror is in front of the mirror.

The principal focus of a convex mirror is a point on its principal axis from which a beam of light rays, initially parallel to the axis, appears to diverge after being reflected from the convex mirror **is called a diverging mirror.** The focus of a convex mirror is situated behind the mirror.

7. Focal length: The distance between the pole (P) and focus (F) is called the focal length. It is denoted by *f*.

8. Focal plane: An imaginary plane passing through the focal point and perpendicular to the principal axis is called the focal plane of the mirror.



9. Real image: The image which can be obtained on a screen is called a real image.

10. Virtual image: The image which can only be seen in a mirror but cannot be obtained on a screen is called a virtual image.

Relationship between the focal length and the radius of curvature of a spherical mirror

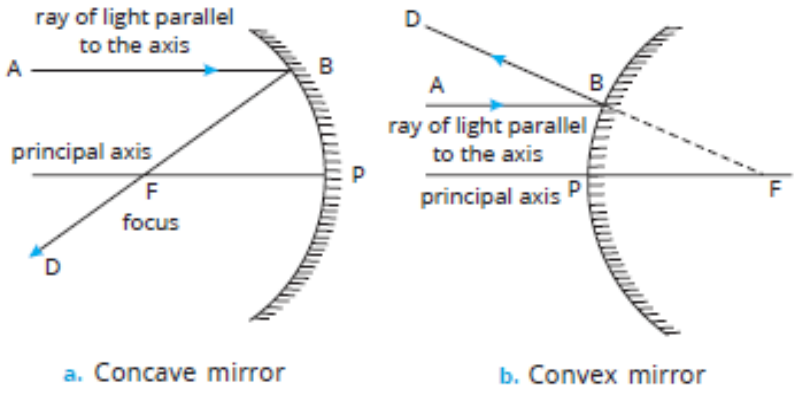
It has been found that the focal length of a spherical mirror (concave or convex) is equal to half of its radius of curvature, i.e.

Focal length = Radius of curvature/ 2 or $f = R/2$

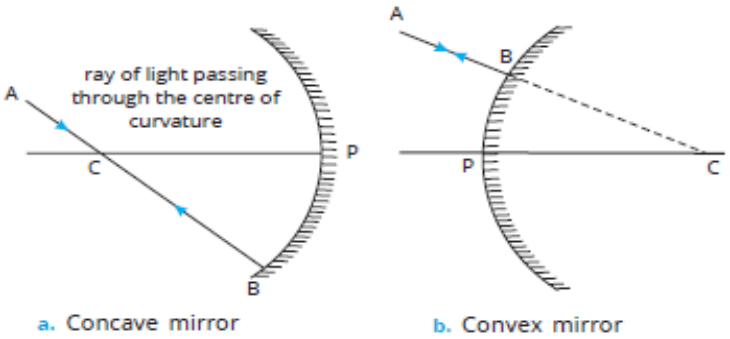
This relationship is true for both concave and convex mirrors.

Rules for the formation of images by a spherical mirror

1. A ray of light which is parallel to the principal axis of a concave mirror, passes through its focus after reflection from the mirror. A ray of light which is parallel to the principal axis of a convex mirror, appears to be coming from its focus after reflection from the mirror.



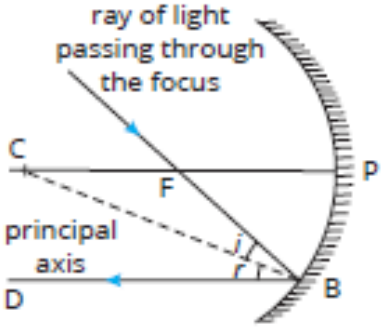
a. Concave mirror b. Convex mirror



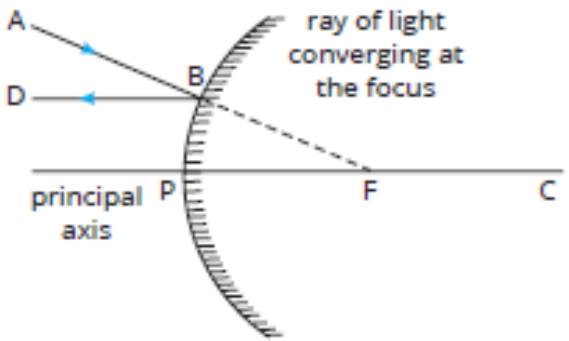
a. Concave mirror b. Convex mirror

2. A ray of light passing through the centre of curvature of a concave or convex mirror, is reflected back along the same path (because it strikes the mirror normally or perpendicularly)

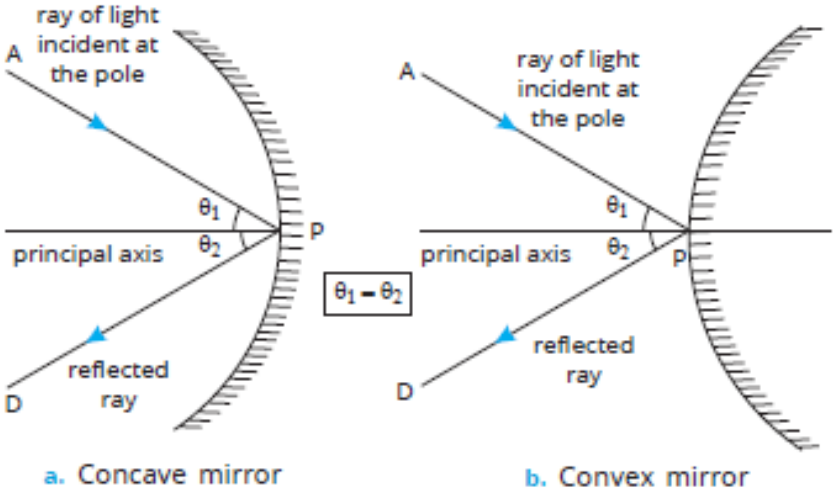
3. A ray of light passing through the focus (in a concave mirror) or converging at the focus (in a convex mirror) becomes parallel to the principal axis after reflection.



a. Concave mirror



b. Convex mirror



a. Concave mirror b. Convex mirror

4. A ray of light incident at the pole P of a spherical mirror (concave or convex) gets reflected along a path such that the angle of incidence is equal to the angle of reflection. In this case, the principal axis itself is the normal at the pole P.

Ray Diagrams for the Formation of Different Types of Images By a Concave Mirror

The position, size and nature of the image formed by a concave mirror depend upon the distance of the object from the pole of the mirror.

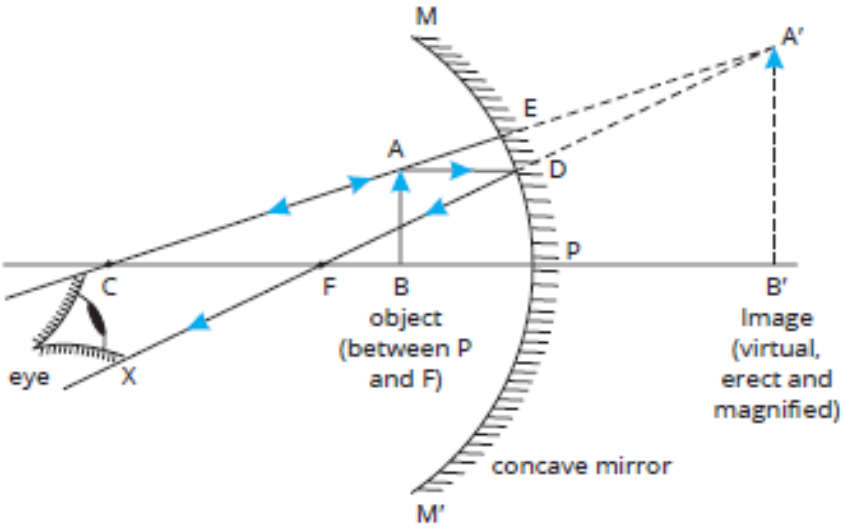
Case I

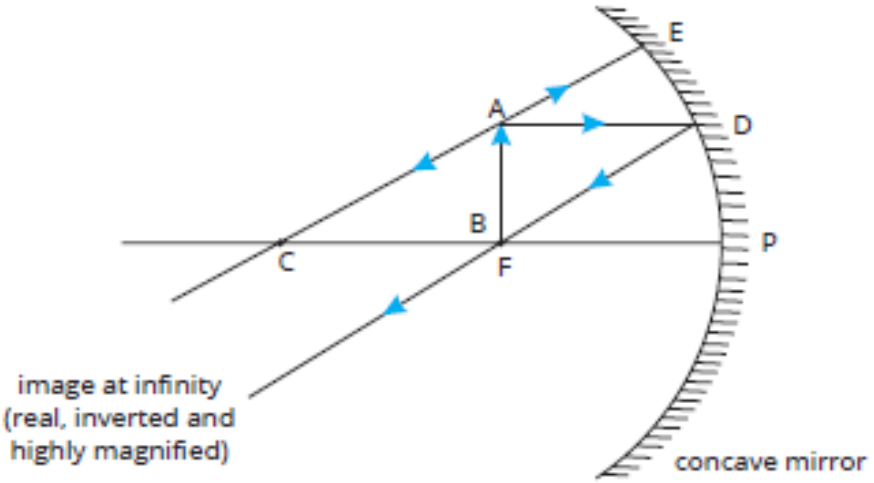
Image formed when the object is placed between the pole (P) and the focus (F) of the mirror

Position: Behind the mirror

Nature: Virtual and erect

Size: Larger than the size of the object (magnified)





Case II

Image formed when the object is placed at the focus (F) of the mirror

Position: At infinity

Nature: Real and inverted

Size: Highly magnified

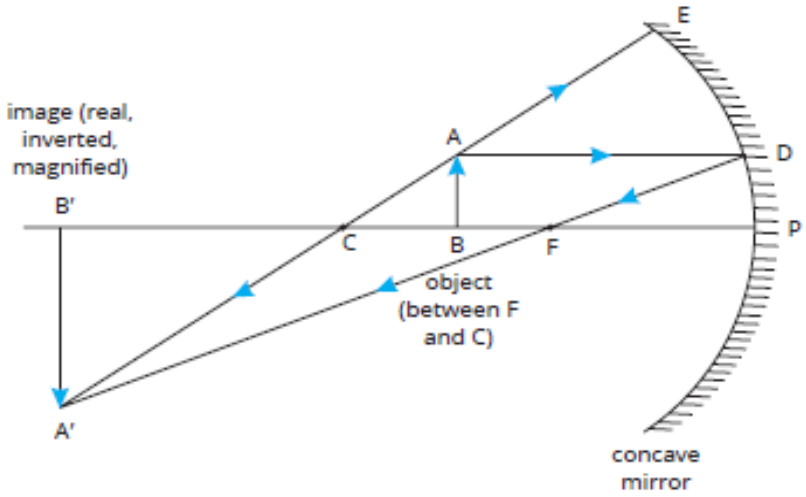
Case III

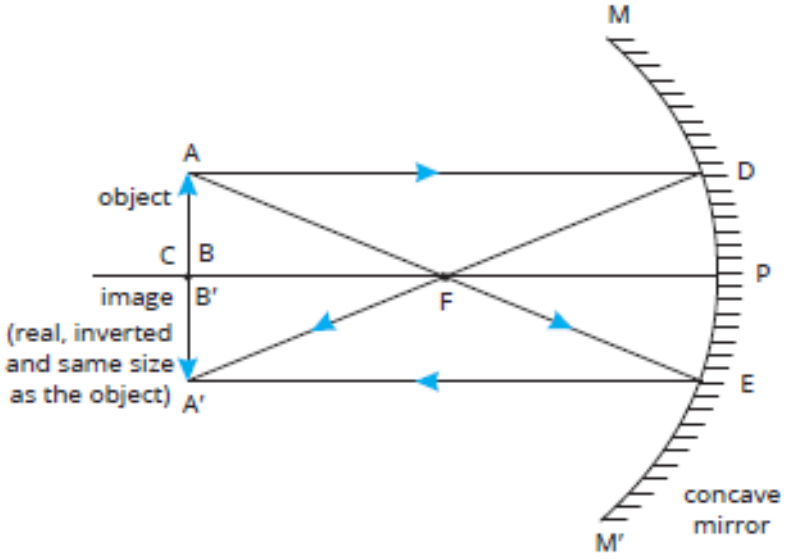
Image formed when the object is placed between the focus (F) and the centre of curvature (C)

Position: Beyond the centre of curvature

Nature: Real and inverted

Size: Larger than the object (magnified)





Case IV

Image formed when the object is placed at the centre of curvature (C) of the mirror

Position: At the centre of curvature

Nature: Real and inverted

Size: Same size as the object

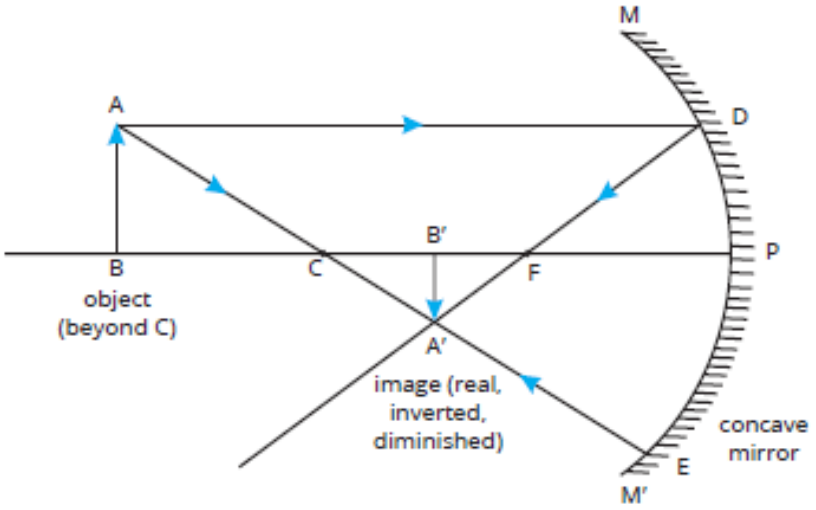
Case V

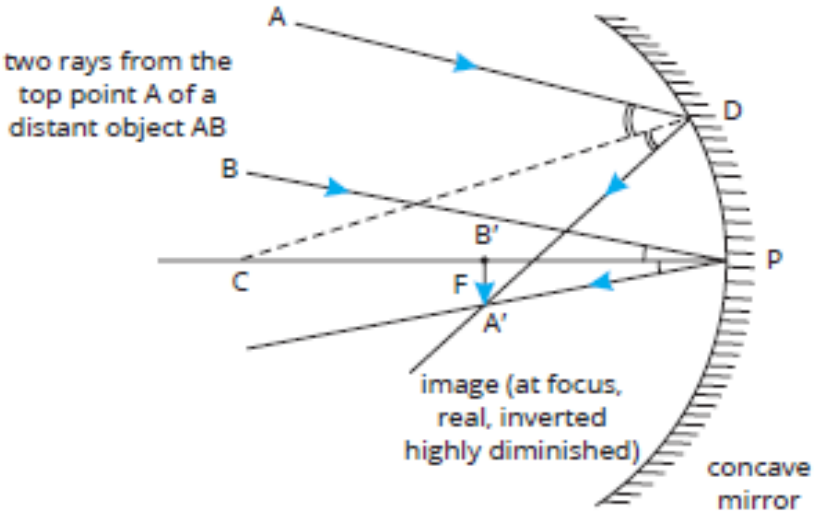
Image formed when the object is placed beyond the centre of curvature (C) of the mirror

Position: Between the focus and the centre of curvature

Nature: Real and inverted

Size: Smaller than the object (diminished)





Case VI

Image formed when the object is at infinity

Position: At the focus (F)

Nature: Real and inverted

Size: Highly diminished

Formation of Images by a Convex Mirror

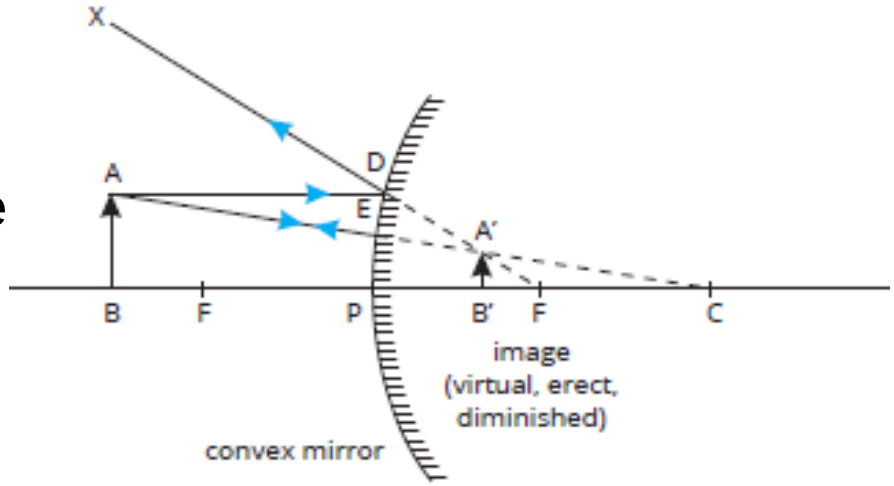
Case I

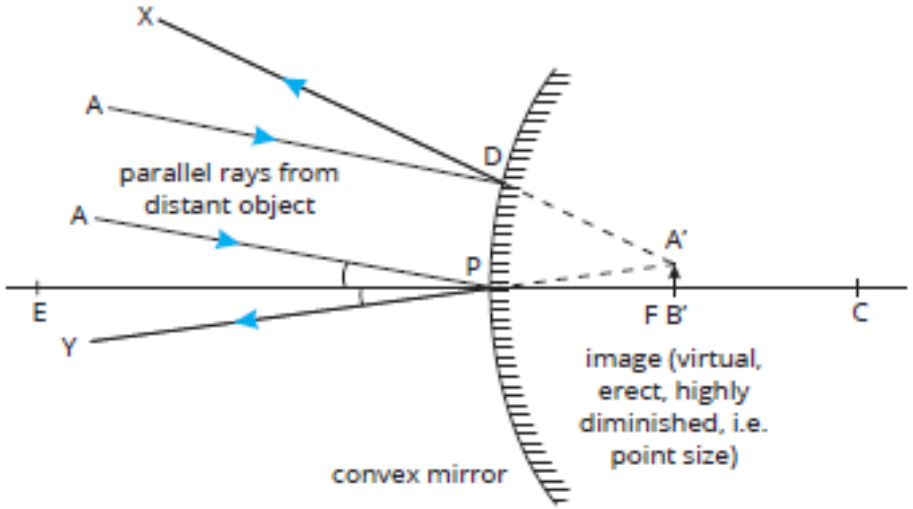
Image formed when the object is placed anywhere between pole (P) and infinity

Position: Behind the mirror between the pole (P) and the focus (F)

Nature: Virtual and erect

Size: Diminished





Case II

Image formed when the object is placed at infinity

Position: Behind the mirror at the focus (F)

Nature: Virtual and erect

Size: Highly diminished

Uses of Concave Mirrors

1. For heating purpose: They are used for converging solar radiations in solar cookers to generate adequate heat for cooking purposes.
2. As reflectors: They are used as reflectors in projectors, lighthouse headlights, searchlights, torches, etc. to obtain a parallel beam of light.
3. As shaving mirrors: Concave mirrors are used as shaving mirrors and as make-up mirrors to see the enlarged, erect image of the face
4. As doctor's head mirror: Concave mirrors are used by doctors to focus light on the internal body parts such as teeth, ear, nose and throat.
5. In floodlights: In a floodlight, a bright bulb is positioned between F and P of a concave mirror to obtain a divergent beam.

Uses of Convex Mirrors

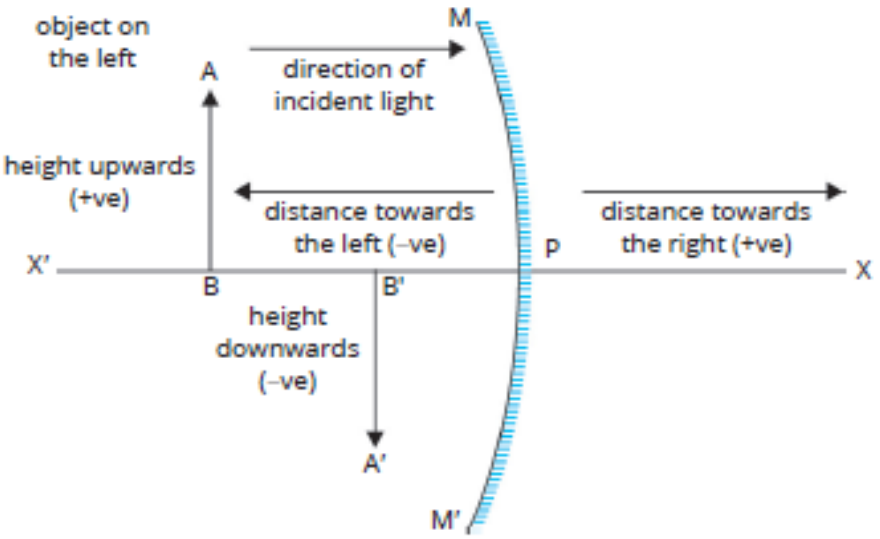
1.As rear-view mirrors: Convex mirrors are used as rear-view mirrors in vehicles like cars, trucks and buses to see the traffic at the back.
2. Safe view of dangerous corners: They are placed on the staircase of the double-decker buses or at staircases to have safe view of the dangerous corners while climbing.

3. Vigilance mirrors: Convex mirrors are used as vigilance mirrors in big shops and departmental stores as **anti-shoplifting devices**.

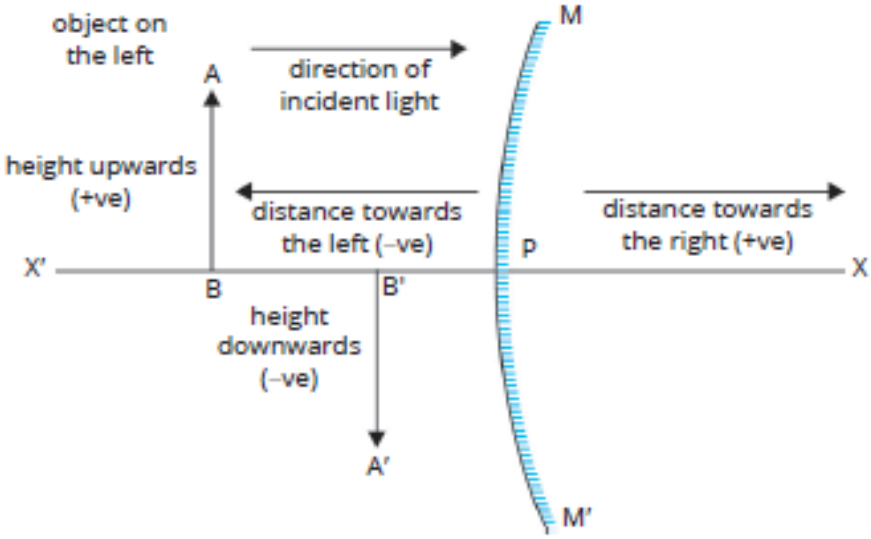
4. Street lighting: Streetlights also use convex mirrors to diverge light over an extended area.

Note: Refer to Table 10.4 for Comparison of the images formed by concave mirror and convex mirror.

New Cartesian Sign Convention



a. Concave mirror



b. Convex mirror

Mirror Formula

The relationship between the distance of the object from its pole (u), the distance of the image from its pole (v) and focal length (f) of a spherical mirror is given by the mirror formula which is expressed as

$$1/v + 1/u = 1/f$$

This formula is valid in all situations for all spherical mirrors for all positions of the object.

SUMMARY

1. Spherical mirror: A spherical mirror is that mirror whose polished, reflecting surface is the part of a hollow sphere of glass.

2. Centre of curvature (C): The geometric centre of the hollow sphere of which the spherical mirror is a part is called the centre of curvature of the spherical mirror.

3. Radius of curvature (*R*): The radius of the hollow sphere of which the spherical mirror is a part is called the radius of curvature (*R*) of the spherical mirror.

4. Principal axis: The straight line passing through the centre of curvature and the pole of a spherical mirror is called its principal axis.

5. Focus (F): The principal focus is a point on the principal axis where the parallel rays of light meet after reflection from a concave mirror (or appear to come from during reflection from a convex mirror).

6. Focal length (*f*): The distance between the pole (P) and focus (F) is called the focal length.

7. Real image: When the rays of light after getting reflected from a mirror actually meet at a point, a real image is formed. It can be obtained on a screen.

8. Virtual image: When the rays of light after getting reflected from a mirror appear to meet at a point to form an image, then the image formed is called a virtual image. It cannot be obtained on a screen.

9. Uses of concave mirrors: a. For heating purposes **b.** As reflectors **c.** As shaving mirrors **d.** As doctor's head mirror **e.** In floodlights.

10. Uses of convex mirrors: a. As rear-view mirrors **b.** For safe view of dangerous corners **c.** As vigilance mirrors **d.** In street lighting.